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(71) Applicant *(for all designated States except US)*: METSÄ-SERLA OYJ [FI/FI]; Revontulentie 6, FIN-02100 Espoo (FI).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: VIKMAN, Kai [FI/FI]; Kaskitie 2, FIN-08800 Kirkniemi (FI).

(74) Agent: SEPPO LAINE OY; Itämerenkatu 3 B, FIN-00180 Helsinki (FI).

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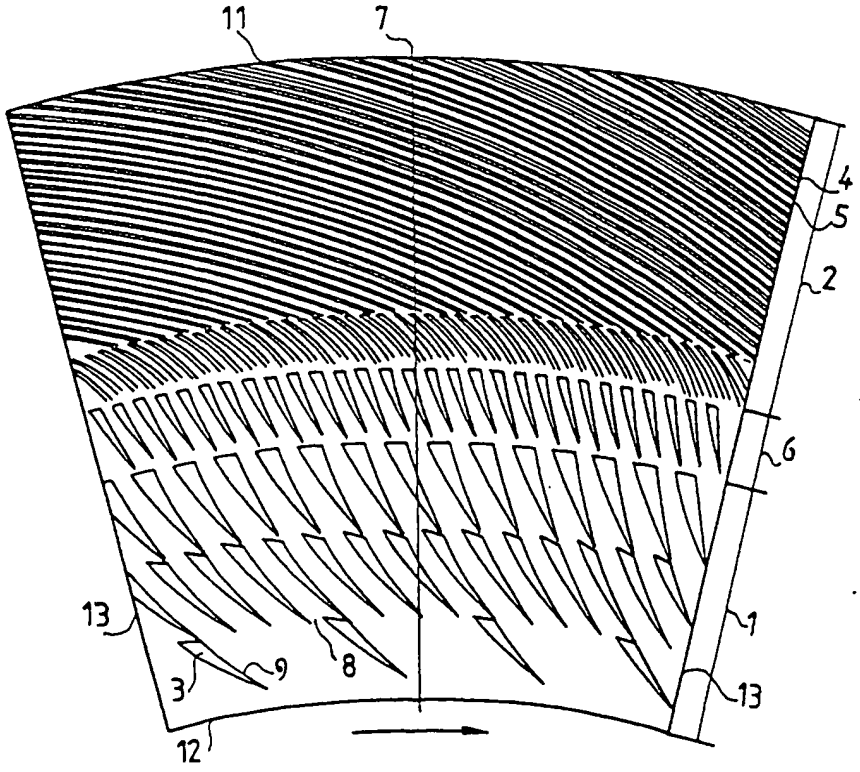
(54) Title: REFINER DISK SEGMENT

(57) Abstract

The invention relates to a refiner disk segment suitable for use in the manufacture of paper or board, the segment comprising a circumferential segment part of a refiner disk surface, the segment part being delineated by an outer edge (11) forming the outer circumference thereof, an inner edge (12) forming the inner circumference thereof and radially straight ends (13) joining the ends of said portions of the segment inner/outer circumference. The refining disk segment surface has teeth (3, 4) mounted thereon with grooves (5, 8) remaining between said teeth, and at least one ring (2) is formed from said teeth (3, 4) for refining the material to be processed. The teeth (4) of at least one ring (2) are formed by at least one arc portion of a continuously arcuate shape that is oriented forward in the direction of disk rotation so as to impart the exiting material a high radial velocity toward the perimeter (11) of the segment.



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Refiner disk segment

The present invention relates to a refiner disk segment according to the preamble of claim 1 for making mechanical fiber mass used in the manufacture of paper or board.

The manufacture of mechanical pulp and mass by grinding requires substantial amounts of energy. Energy is consumed as mechanical drive power of the refiner and as process steam. The refiner is rotated by electrical power, and frequently also the required steam is generated by electricity, which means high specific energy consumption of electricity. During grinding, a major fraction of energy is converted into steam. The high specific energy consumption is basically caused by three reasons: 1) the entire process operates at an inferior efficiency, whereby energy is converted into heat; 2) due to the low efficiency of the process, the released heat must be conducted away, whereby cooling is carried out using steam introduced into the refiner after being generated with electrical energy, so naturally energy must be consumed in steam generation; and 3) steam is also used for transporting the fiber mass in the refiner. Moreover, the pressure and temperature in the refiner disk gaps reach high values with pressures exceeding 7 bar (0.7 Mpa), which requires both the refiner and the process to be dimensioned to take the load of high forces. Refiner pressure and temperature also affect the fiber quality and physiological properties, and with increasing pressure and temperature, also the fiber brightness decreases and the content of nonsolubles (COD) increases. Also the fiber distribution becomes difficult to manage. The dwell time of fibers in the refiner is long, which is an indication of inferior efficiency.

A refiner employed in the manufacture of mechanical mass

comprises two opposed refiner disks. The cutting surfaces of the refiner disks are composed of replaceable segments in which the grinding/refining teeth form grooves and ridges. One disk of the refiner has an opening in the center of its support shaft via which the material (typically chips) to be ground is passed into the refiner. The clearance between the refiner disks is largest at the center of the disks and narrows toward the perimeter thus effecting a gradually higher degree of material defibering. The grooves and ridges of the refiner disk teeth can be aligned radially or inclined at an oblique angle with the disk radius. Downstream smooth inclination of the grooves, that is, at a backward angle with the direction of disk rotation will reduce the energy consumption, while inclination of the grooves toward the direction of rotation increases the rotational load of the refiner disks.

The contouring of refiner disk surfaces has theoretically been considered to affect the quality of produced finer mass. Straight, radial grooves increase the yield of long fibers as herein the fibers are separated from each other chiefly by axial grinding and rotation of fiber bundles in the grooves. Resultingly, refiner disks with radial grooves prepare a long-fiber mass suitable for use in high-strength paper grades. Refiner disks with obliquely running grooves respectively prepare a short-fiber mass of finer distribution for high-quality paper grades of good printability. In practice, the effect of refiner disk groove orientation may not necessarily be essential to the fiber composition of mechanical mass, but rather, other factors will determine the type of mass obtained from the refiner.

Specific energy consumption is very high in a refiner with radial refiner disk grooves. In contrast, a refiner with obliquely inclined refiner disk grooves has a

smaller specific energy consumption and the disk grooves cause a centrifugal pump effect capable of transporting fibers radially outward in the gap between the refiner disks. Then, the amount of steam used for transporting the fibers can be reduced and also the overall energy consumption is lower. Due to the pumping effect, the dwell time of fiber mass is shorter and a brighter mass is obtained due to the shorter dwell time, lower grinding pressure and lower temperature.

US Pat. No. 5,362,003 discloses a refiner segment having the segment radially divided in at least two refining zones, whereby the angle of the refining grooves with the disk radius is in each radial zone made different from that of the adjacent zone. In the inner radial zones, a relatively large angle with the disk radius is used, while in the outer zone an almost radial angle is used. In this manner, the inner refining zones are imparted a centrifugal pump property which gives a reduced specific energy consumption.

It is an object of the present invention to provide a refiner disk segment offering a substantial reduction of specific energy consumption in the manufacture of mechanical mass.

The goal of the invention is achieved by forming the grooves and ridges of the refiner disk segment from curved continuous arc portions inclined forward in relation to the direction of rotation of the refiner disk.

According to a preferred embodiment of the invention, the segment is divided into at least two zones.

More specifically, the refiner disk segment according to the invention is characterized by what is stated in the

characterizing part of claim 1.

The invention offers significant benefits.

The most important advantage of the invention is a substantial reduction of specific energy consumption. According to tests performed, up to 15 % specific energy reduction is possible in a first-stage refiner; and if the invention is applied to all the refining stages, the savings attainable will increase correspondingly. Additionally, in refiners using a two-stage, turbine-like construction of the refiner disk segment, the radial acceleration component of finer mass can be increased, whereby a further reduction of specific energy consumption will be attained. The dwell time of the fiber mass in the refiner will be shortened due to the higher radial acceleration, whereby also the amount of steam required for finer mass transport is reduced, and simultaneously, the loss of fiber mass brightness is smaller and the amount of nonsolubles is lowered. Also the internal pressure and temperature in the refiner are lowered. These factors have a direct effect on the finer mass brightness and energy consumption as well as the need of installed drive power and strength dimensioning in the refiner, thus permitting a refiner based on the refiner disk segment according to the invention to be designed for lower loads. Teeth with the shape of continuous, smoothly-curved arcs provide a substantially higher centrifugal pumping force over that available by means of obliquely inclined straight teeth. According to one embodiment of the invention, it has been attempted to concentrate the pumping effect of the refiner on the outer or outermost refiner disk zones, where the tangential velocity is higher than at the center of the refiner disk, thus correspondingly giving the teeth a more effective pump effect.

In the following the invention will be examined in greater detail with the help of the appended drawings in which

Figure 1 shows an embodiment of the invention in a top view; and

Figure 2 shows in a cross-sectional view of the embodiment illustrated in Fig. 1.

In Figs. 1 and 2 is shown a refiner disk segment representing a circumferential segment part of a refiner disk surface. The full ring of the refining disk surface is assembled from a set of these segments. Resultingly, a single segment is delineated by an outer edge 11 forming the outer circumference, an inner edge 12 forming the inner circumference and radially straight ends 13 joining the ends of said portions of segment inner/outer circumference. In the refiner, the segments are mounted in place by means of bolts screwed into threaded holes.

The refiner disk segment shown in Figs. 1 and 2 is formed by two ring portions 1, 2, of which the inner ring portion is a large-toothed grinding ring 1 and the outer is a small-toothed ring acting as the refining ring 2 proper. The radial width of the grinding ring 1 is narrower than that of the refining ring 2, thus making the dwell time of the fibrous material being ground therefrom in the region of the grinding ring 1 shorter than in the region of the refining ring 2. The teeth 3 of the grinding ring are relatively large and arranged from separate teeth into kind of a saw in order to obtain more efficient grinding of chips. Each tooth 3 is contoured into a continuous smoothly-curved arc so that the inner side of the concave arcuate tooth is toward the direction of rotation of the refiner disk. The radial alignment of the arcuate tooth in relation to the radius 4 of the

grinding ring is such that the arcuate shape of the tooth converges toward the radius 7 in the radial direction. In other words, the angle of the tangent of the tooth arc becomes smaller in the radial direction. This arrangement imparts the material being ground an initial velocity in the radial direction that effectively transports the material toward the refining ring 2 inasmuch the teeth of the inner ring function in a similar manner as the blades of a centrifugal pump. On the other hand, this requires that the concave shape of the tooth arc is oriented toward the direction of rotation of the refiner disk, which causes the shape of the tooth to cause greater resistance to the rotation of the refiner disk. Owing the relatively small tangential velocity and radius of torque along the inner ring 1 in relation to the center of the refiner disk drive shaft, the energy loss caused by this inverted shape of the tooth remains, however, rather insignificant. The energy savings resulting from the increased tangential exit velocity of the ground material from inner ring more than compensates for said loss component.

In the radial direction, the inner ring 1 is followed by an intermediary ring 6 serving to guide the ground material to the outer ring 2.

On the outer ring, which is the refining ring 2 proper, the curved shape orientation of the teeth is changed to be convex in relation to the direction of rotation of the refiner disk and the tangent of the tooth shape with the radius 7 approaches a right angle toward the perimeter of the outer ring. In other words, the tangential angle of the teeth of the refining ring 2 in relation to the disk radius 7 increases with the radial distance from the refiner disk center. At the perimeter of the refiner disk segment, the tangent of the tooth 4 is already almost square with the radius. This arrangement gives the fiber

mass leaving the refining ring a high radial velocity inasmuch the curved teeth 4 by virtue of their shape eject and propel radially outward the fiber mass contained in the space between the opposed refining rings. This shaping of the refining ring tooth results in a reduced specific energy consumption because of backward-inclined orientation of the teeth 4 in relation to the direction of rotation of the refiner disk and because of the higher radial transport velocity of the fiber mass resulting in a shorter dwell time and reduced steam consumption for fiber mass transport. Owing to the same reasons, also the energy required for preparing a given amount of fiber mass is reduced. While the outer ring in the described embodiment is formed by two rings of teeth of differently arcuate shapes, it may as well comprise only a single interleaved ring of teeth having a suitably dimensioned curvature and radial change of teeth curvature.

Both the thickness and lateral height of the teeth in the first and second rings are varied along the disk radius. Correspondingly, the clearance between the refiner disks changes. For instance, the clearance between the teeth of the opposed refiner disks may be 5 mm at the inner perimeter of the grinding ring and taper to about 1 - 2 mm at the outer perimeter of the ring. Hence, the segment and the base surface thereof on which the teeth are mounted must be conical as shown in Fig. 2.The purpose of the tapering clearance and radially decreasing height of the teeth 3, 4 is to provide a gradually finer defibering of the processed material toward the outer perimeter of the refiner disk. The groove 5 between the teeth 4 of the grinding ring 2 becomes narrower and shallower radially outward, while the width of the groove 8 between the teeth of the refining ring 1 stays constant radially outward with a simultaneously decreasing depth of the groove. The concave inner surface 9 of the teeth 3 of the

grinding ring 1, which is the tooth surface facing the direction of rotation of the refiner disk, may be slanted laterally, and the teeth 3 may have notches that divide the tooth rings into periods. Such a slanted surface and notched arrangement of the teeth help eject the material away from the intertooth spaces via the gap 8 formed between the teeth 3, whereby the material is subjected to regrinding.

In a teeth arrangement according to the invention, the material flow in the radial direction takes place in a similar manner as in a multistage turbine. From the first ring 1 (first stage), the exiting flow hits, after being guided by the teeth 3 via the intermediary ring 6, the reaction vanes formed by the teeth 4 of the second ring 2, whereby the inertial energy of the flow imparts a thrust on the teeth of the second ring 2 in the direction of rotation of the refiner disk, thus reducing the need of installed drive power for rotating the refiner. A similar effect can be attained by using a number of concentric refiner disk segments in which the flow is controlled in a corresponding fashion. However, there must be radially adapted a stationary ring of guide vanes or teeth between the concentrically rotating segments in order to guide the direction of the reaction flow parallel to the tangential direction of rotation of the refining ring.

Besides those described above, the present invention may have alternate embodiments.

For instance, the curved shape of the teeth of ring segments and the curvature thereof that determines the shape of the intertooth grooves may be varied. The teeth of the outer ring may be oriented smoothly in the direction of disk rotation so as to impart the exiting material a maximally high radial velocity while

simultaneously causing a minimum resistance to the rotation of the refiner disk. Advantageously, the teeth of the outer ring are formed with a gapless continuously curved shape, because any discontinuities in the tooth shape may interrupt the smooth material flow and cause unnecessary turbulence in the flow. However, it may be contemplated that the shape of the curved tooth is made variable so that, e.g., the tooth on one ring are formed by gaplessly end-to-end connected curved arc portions.

Claims:

1. Refiner disk segment suitable for forming the refining disk surface used in processing and grinding fibrous raw material in the manufacture of paper or board, the segment comprising

- a circumferential segment part of a refiner disk surface, the segment part being delineated by an outer edge (11) forming the outer circumference thereof, an inner edge (12) forming the inner circumference thereof and radially straight ends (13) joining the ends of said portions of the segment inner/outer circumference,

- teeth (3, 4) mounted on said refining disk surface and grooves (5, 8) remaining between said teeth,

- at least one ring (2) formed from said teeth (3, 4) for refining the material to be handled, and

- elements for mounting said refiner disk segment into a part of a refiner disk surface,

c h a r a c t e r i z e d in that

- the teeth of at least one ring are formed by contiguous arc portions in which the tangential angle of the tooth shape with the refiner disk radius (7) decreases toward the perimeter of the refiner disk so that the arcuate shape of the tooth converges toward the radius in the radial direction.

2. Refiner disk segment according to claim 1, c h a r a c t e r i z e d in that the teeth (4) of at least one ring (2) are formed by arc portions in which the tangen-

tial angle of the tooth shape with the refiner disk radius (7) increases toward the perimeter of the refiner disk.

3. Refiner disk segment according to claim 1, characterized in that said segment comprises two concentric portions of refining rings (1, 2).

4. Refiner disk segment according to claim 3, characterized in that the teeth (4) of the outer ring are formed from at least one arc portion oriented in the direction of disk rotation so as to impart the exiting material a high radial velocity toward the perimeter (11) of the segment.

5. Refiner disk segment according to claim 4, characterized in that the teeth (3, 4) of the inner ring (1) and the outer ring (2), respectively, are arranged so that the teeth (3) of inner ring direct the material flow to the inner side of the curved shape of the teeth (4) of the outer ring so as to achieve a reaction flow similar to that of a multistage turbine.

6. Refiner disk segment according to claim 1, characterized in that the teeth of at least one ring have the shape of a continuous smoothly curved arc.

7. Refiner disk segment according to claim 1, characterized in that the teeth of at least one ring are formed from two end-to-end connected arc portions of differently arcuate shape.

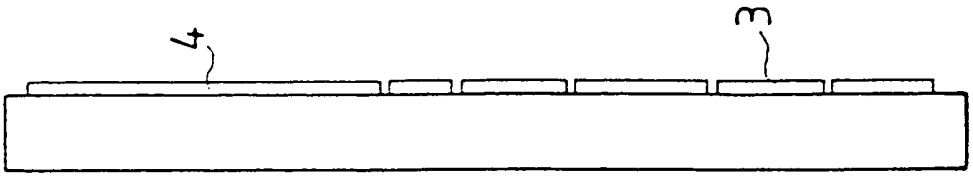
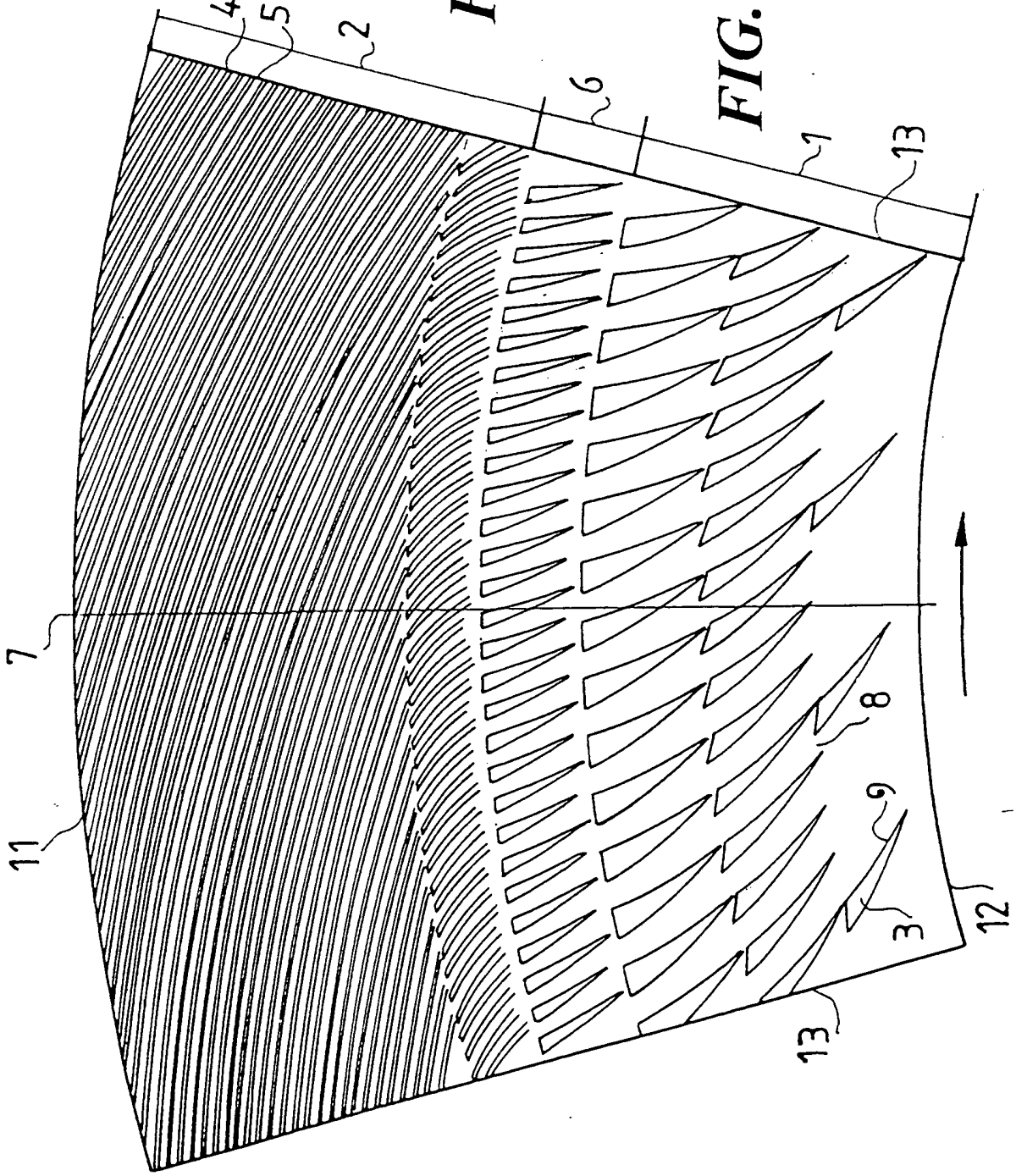


FIG. 2

FIG. 1



INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00308

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B02C 7/12, D21B 1/14, D21D 1/30
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B02C, D21B, D21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ, US FULLTEXT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9723291 A1 (SUNDS DEFIBRATOR INDUSTRIES AB), 3 July 1997 (03.07.97), figures 1,4, claims 1,3	1,3-7
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI99/00308

Claims 1 and 2 do not fulfil the requirements of Art.6, as the present wording implies a contradiction ("decreases", claim 1, page 10, line 30; "increases", claim 2, page 11, line 2). C.f. the description pages 5 and 6, from where the inventive idea can be understood. The search is based on said pages.

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/99

International application No.
PCT/FI 99/00308

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9723291 A1	03/07/97	AU 694898 B	30/07/98
		AU 1215797 A	17/07/97
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